

determine the engineering and economic feasibility of navigation. The Texas Water Plan is compatible with any such development found to be economically feasible.

Recreation

Demands for recreation, particularly for water-oriented recreation, are increasing rapidly in Texas, as the continuing concentration of the State's population in the cities adds immediacy to the urgent need for recreational facilities away from the cities. Lakes and camping and picnic areas are jammed with crowds on weekends and throughout the spring, summer, and fall. Broad based recreational planning now underway must recognize this urgent need.

Recreation is, increasingly, a big business, both for the State and for private investors. Economic analyses by the Board indicate recreation benefits of \$1.1 billion with a cumulative potential of two billion visitor-days to the year 2020 at the reservoirs proposed in the Texas Water Plan. These analyses have shown that benefits from water-oriented recreational developments exceed their costs by a wide margin. It should be recognized also that esthetic and recreational enjoyment of water development projects is not accurately measurable by dollar value.

Recreation has been an important factor in planning for Texas water resource development. Water planning by the Board, developed concurrently with the

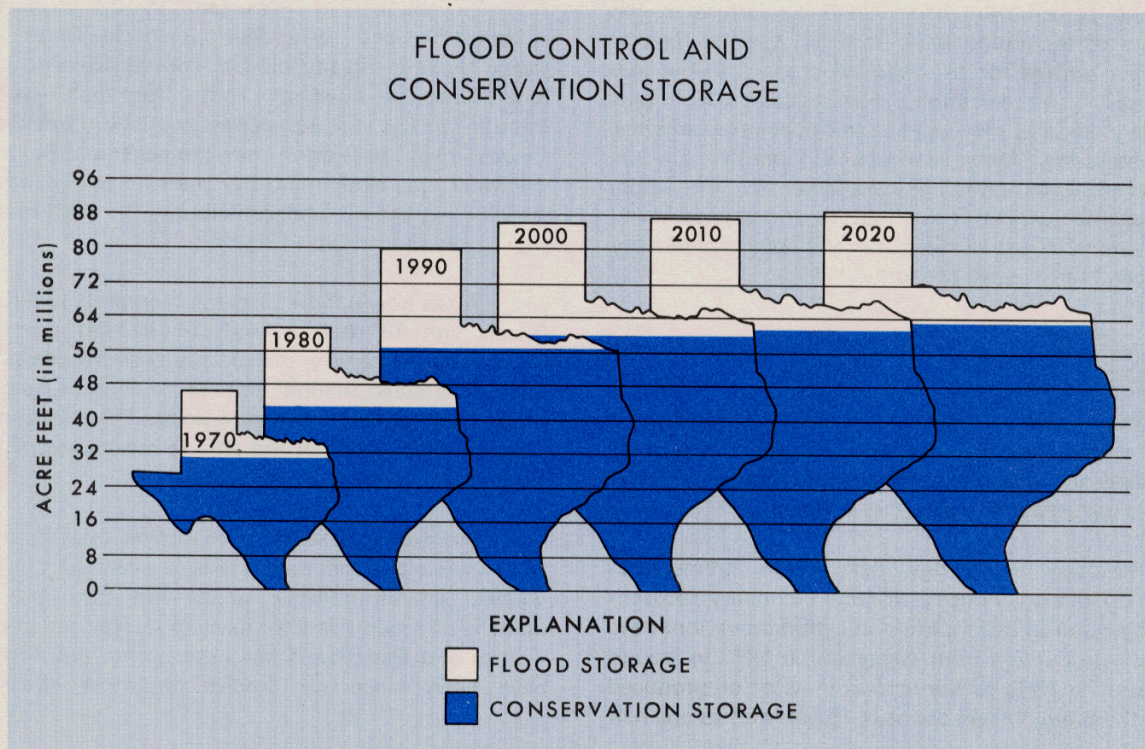
formulation by the Parks and Wildlife Department of a comprehensive outdoor recreation plan for Texas, takes full cognizance of the recreational value of potential reservoir development proposed under the Texas Water Plan.

Flood Control

Floods in Texas have historically caused widespread suffering, major losses of life, and damage in both urban and rural areas.

Some 320 Texas cities have flood problems resulting from stream overflow, local drainage, or coastal floods. One hundred of these cities have stream overflow flood problems, 112 have local drainage problems, 20 have coastal flood problems, and another 88 have some combination of these.

The worst general floods of recent years were in 1957 when every major river and tributary in the State flooded during the spring months between April and June. In late April 1966, intense flooding occurred in northeast Texas where 20 to 24 inches of rain fell in some areas in a relatively short period of time. Flash flooding in the Sanderson area in 1965 cost 24 lives in a period of hours. Severe flooding occurred in South Texas from heavy rainfall accompanying Hurricane Beulah in 1967.



The Federal Flood Plain Management Program, enacted by Congress in 1960, is directed toward assisting cities to alleviate flood problems. The purpose of the Program is to provide a basis for sound zoning ordinances and subdivision regulations in cities with flood problems by defining the flood plain limits under flood conditions. The Board examines applications for assistance under the Program, assigns priorities for project formulation, and the studies are made by the Corps of Engineers. As of August 31, 1968, seven such studies had been completed and seventeen were underway.

Flood control measures proposed in the Texas Water Plan, developed cooperatively with the U.S. Army Corps of Engineers, include flood control storage in reservoirs, channel improvements and modifications such as levees, and other measures adapted to particular flood problems in specific areas.

Upstream Flood Retardation and Watershed Protection

Two-thirds of all agricultural lands in the State are subject to serious erosion or the threat of erosion. Effective land use and soil, water, and plant conservation measures are essential to protect agricultural production capacity, and to reduce sedimentation in reservoirs, stream channels, and coastal waters.

Under the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, as amended), the Soil Conservation Service of the U.S. Department of Agriculture provides technical and financial assistance for land treatment, flood prevention, and the conservation, development, utilization, and disposal of excess water on watersheds up to 250 thousand acres.

Watershed plans developed to implement this and other Acts include land treatment measures as well as structural control measures. The soil and water conservation measures on the land must precede or accompany installation of floodwater-retarding structures and drainage and irrigation facilities.

The State agency with responsibility for the land conservation program is the State Soil and Water Conservation Board. That agency and the Board have closely coordinated their activities and those of the Soil Conservation Service since the passage of the Texas Water Planning Act of 1957, including the studies of the current planning program.

As of April 1, 1968, watershed plans had been approved and work had been completed or was in progress on land totaling about 13½ million acres. Plans have been authorized by Congress for work on additional watershed areas totaling about 1¼ million acres.

Drainage

Many areas of the State have drainage or wetland problems, particularly in the Lower Rio Grande Valley and in the coastal areas of other river basins, including the intervening coastal basins. Many small coastal cities—Rockport and Aransas Pass, among others—have serious urban drainage problems. Investigations made by the Soil Conservation Service in 1961 and 1965 indicate a total of 16.6 million acres of wetlands. Much of this area is frequently flooded bottomland, marshlands, and tidewater swamps situated too low in relation to possible outlets to drain properly or to be drained. No drainage improvement is contemplated for such areas, their most beneficial uses being as natural habitat for fish and wildlife species. Other lands are subject to frequent inundations from river and creek flooding and will require extensive protection facilities to prevent flooding before drainage improvement measures can be installed.

Summary drainage reports by the Soil Conservation Service show that drainage improvement is considered to be feasible for a total of over 7.8 million acres in Texas. About 11.5% of this total has had adequate drainage improvement to April 1968.

Hurricane Protection

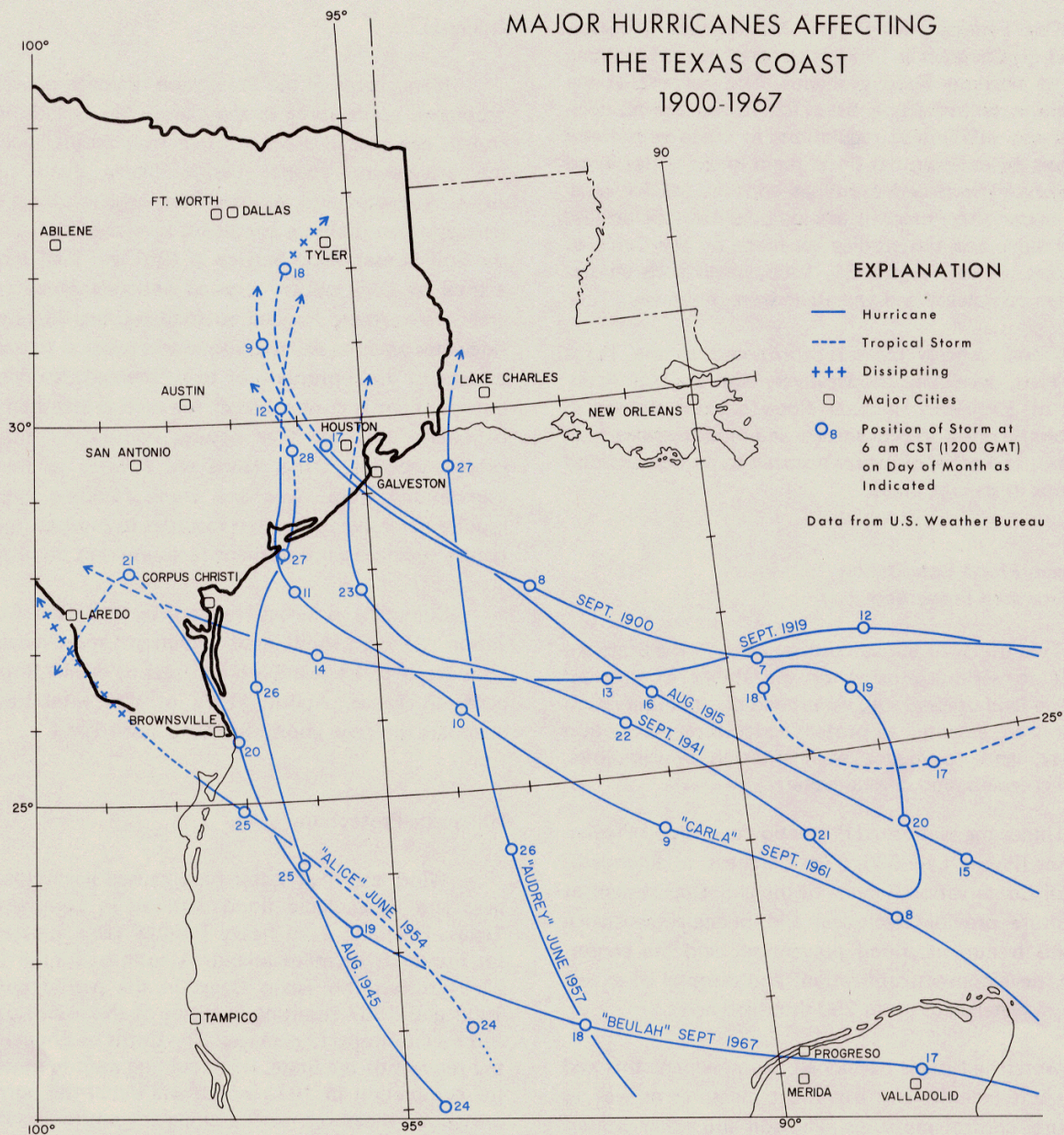
Wind and high water have caused heavy losses of lives and incalculable flood damages in Louisiana and Texas. Flooding from heavy residual rains is often felt for hundreds of miles inland. A total of 33 hurricanes have crossed the Texas Coast in the period between 1900 and 1967 resulting in losses of thousands of lives and severe property damages. The Corps of Engineers, at the request of the State, is conducting a study scheduled for completion in 1973 which will detail the hurricane protection measures needed along the entire Texas Gulf Coast. This study, designed to result in measures which will reduce hurricane damage along the Coast, is extremely important to continued urban and industrial development.

Water Quality

Presently available water quality data indicate some areas of Texas streams and ground water aquifers where quality of water is impaired. Inorganic pollutants, both natural and man-made, probably now constitute a more widespread problem than do organic materials from municipal and industrial wastes.

In planning, those areas were defined where water quality problems exist and which must be corrected in

MAJOR HURRICANES AFFECTING THE TEXAS COAST 1900-1967



whole or in part, and other areas where water quality problems do not presently occur but where full stream development may have adverse effects on quality. Serious degradation of sanitary quality occurs in parts of four river basins—the Trinity, San Jacinto, San Antonio, and the Rio Grande.

It has been assumed as a concept of planning that the highest economically feasible techniques of municipal and industrial waste treatment will be utilized, that pollution resulting from oil field brines will be eliminated over time, and that agricultural practices will be improved to eliminate pollution problems to the extent feasible under existing technology.

Conventional waste treatment techniques in some areas may not meet this conceptual premise, and may be inadequate to maintain established stream quality standards. Centralization of all urban sewage treatment systems in a large city, or consolidation of the systems of several smaller cities probably offers more promise than any other approach to effective pollution control. Whatever alternative or level of treatment applied, it is apparent that use of the full assimilative capacity of streams is not a practical long-term solution for the final treatment of municipal and industrial waste effluents. Increasingly, this assimilative capacity will be required to accommodate pollution from land runoff which is beyond practical control.

Capital costs for treatment of municipal wastes at a level adequate to combat pollution problems throughout the State are estimated as high as several hundreds of millions of dollars during the next decade. Although only limited estimates are available of the costs to industry and cities for water treatment processes required to make water suitable for use, there is no question that they run into the hundreds of millions of dollars also.

Bays and Estuaries

The Board is aware of an impact from the changes in volumes of water from streams entering the bays resulting from upstream reservoir development and water utilization, continually increasing return flows, and changing conditions of surrounding land development on water quality in the bays and estuaries along the Texas Gulf Coast.

The economic urgency for finding meaningful solutions to these problems is demonstrated by the increased value of commercial and sports fishing in the estuarial environment, now estimated at more than \$150 million annually, more than 99% of which is derived from the catch of species dependent on the estuarine environment at some point in their life cycle. The related economic return to the State from tourism attracted to the bay areas is estimated at \$300 million annually. All of this can be lost to the State if some solution for preserving the ecology and esthetic quality of the bays is not found.

Studies to find feasible solutions and concepts compatible with maximum upstream development of Texas water resources have shown that fresh water inflows and reduction of pollutants are not the whole solution. Other factors, including circulation within the bays themselves, land runoff, and hydraulic interchange with Gulf waters, all have profound effects on bay conditions.

An intensive study has been undertaken of the Galveston Bay complex by the Texas Water Quality Board in cooperation with many Federal and State agencies. The results of this study, and detailed studies on the other bays, may provide long-range solutions to the complex bay and estuarial needs. In 1967, the Board and the U.S. Geological Survey began a three-year comprehensive data collection program designed to aid in defining the quality and hydraulic characteristics of the bays. The total cost of this program is in the order of \$400,000. Meanwhile, reasonable fresh water inflows are provided to the bays and estuaries on an interim basis while their long-range needs are determined by these detailed studies.

Fish and Wildlife

Traditionally Texans have enjoyed access to excellent fishing and hunting opportunities. Cultural developments such as cities, highways, airports, and reservoir projects may intrude on valuable ecological areas and habitat. Whenever damage occurs, measures for mitigating these damages must be assessed. Where possible, the potential of water development for enhancing the fish and wildlife resource must be achieved. Most importantly, programs of fish and wildlife management and cultivation will provide a continuing increase in the hunting and fishing potential.

Scenic and Scientific Areas

Texas is endowed with extremely beautiful scenic areas and areas of unique scientific value. Some of these areas have been lost by urban expansion, highway and utility development, or may be threatened by development of reservoirs or water conveyance facilities.

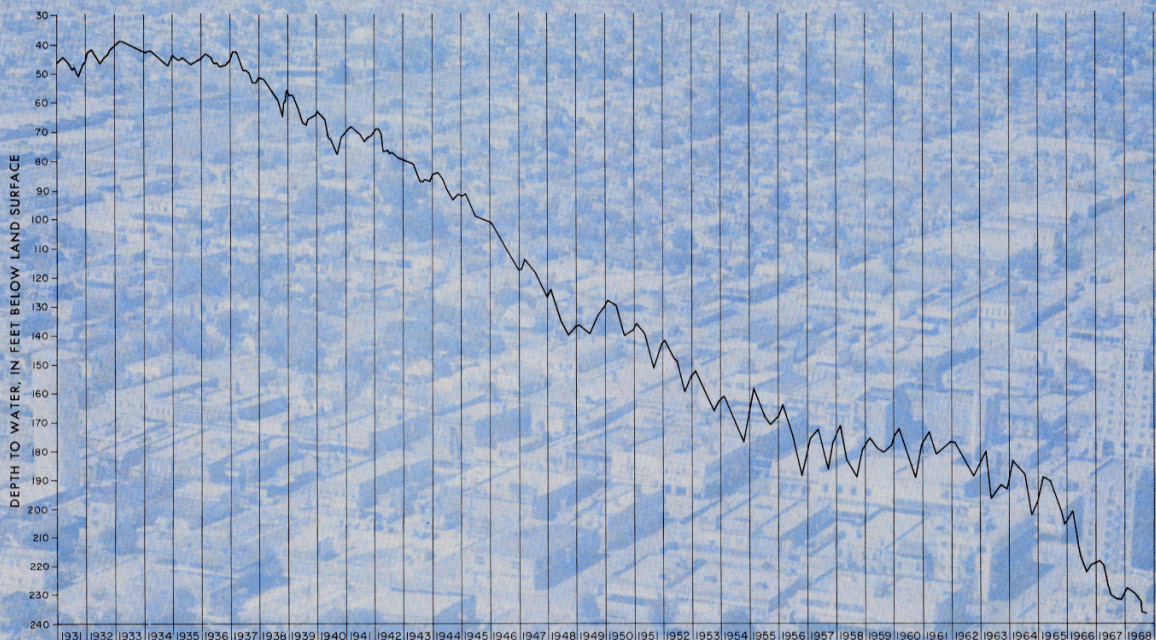
The Board recognizes its responsibility to minimize this loss of natural beauty and scientific value to the State as it might result from water development. As a part of the Texas Water Plan, therefore, the Board recommends that a systematic effort be made to preserve these assets for future generations.

Subsidence and Saline Water Intrusion

In some areas of Texas, withdrawals of large volumes of ground water have resulted in adverse effects. Major effects which may limit further ground water development in these areas are: (1) the intrusion of saline water into the areas of heavy withdrawal, a problem in many areas of the State; and (2) land subsidence, which is principally of concern in the Gulf Coast area.

Many fresh water aquifers are closely associated with saline water aquifers which may either overlie, underlie, or occur in areas down dip of the fresh water aquifers. Where such fresh water aquifers are heavily pumped, saline water has moved towards pumping wells, resulting in the deterioration of the quality of fresh water. A significant example of saline water encroachment is in the Texas City-Galveston area where deterioration in water quality already has been noted in some wells. It is important that the positions and rates of movement of saline water in problem areas be given careful study. Studies are underway to optimize ground water withdrawals to limit saline water encroachment in order to extend the useful life of the aquifers.

STEADY WATER LEVEL DECLINE FROM CONTINUED HEAVY MUNICIPAL AND INDUSTRIAL PUMPING GULF COAST AQUIFER, HARRIS COUNTY



Subsidence of the land surface as a result of pumpage of large volumes of ground water has already become a particularly acute problem in several areas along the Texas Gulf Coast. As the artesian pressure head in these deeply buried aquifers is reduced by large withdrawals of ground water, the skeletal framework of the aquifers is altered and the beds compressed by the weight of the overlying rocks. Land subsidence is presently most pronounced in local areas near Pasadena, Baytown, and Texas City where as much as five feet of subsidence has occurred. Loss of freeboard on hurricane

protection facilities may result from such subsidence. Drainage and flooding problems during periods of wet weather have resulted in many places as a consequence of subsidence. Damage to municipal utility lines and other facilities has occurred. Studies will be continued to define the relationship between ground water withdrawals, pressure head decline, and subsidence so that more accurate projections of the magnitude of future subsidence problems can be made and both saline water encroachment and land subsidence can be minimized in these areas.